Development of Improved Aerogels for Spacecraft Hypervelocity Capture - C.M. Lisse[1], A.F. Cheng[1], N. L. Chabot[1], N. Dello Russo[1], J.H. Satcher[2], M.E. Zolensky[3], M.J. Cintala[3], D.P. Glavin[4], S.A. Sandford[5]. JHU-APL, 11100 Johns Hopkins Road, Laurel, MD 20723 carey.lisse@jhuapl.edu. [2]Chemical Sciences Division, LLNL, 7000 East Ave., Livermore, CA 94550 satcher1@llnl.gov [3] Astromaterials Research and Exploration Science, KT, NASA JSC, Houston, TX 77058 michael.e.zolensky@nasa.gov [5]NASA GSFC, Code 699, Greenbelt MD 20771 Daniel.P.Glavin@nasa.gov [5]Astrophysics Branch, NASA ARC, Moffett Field, CA 94035 ssandford@mail.arc.nasa.gov

Introduction: The highly successful NASA Discovery mission Stardust became the first mission to return samples to Earth from a known comet in January 2006 [1]. The samples were captured during a flyby of comet 81P/Wild2 using aerogel, a very low density, silica (SiO2)-based solid with a highly porous structure [2]. Currently, scientists around the world are studying the cometary particles returned by Stardust and reporting fascinating discoveries about the history of comets and the evolution of our solar system. Given the widely acknowledged success of the Stardust mission, additional comet sample return missions are attractive and competitive concepts for future NASA Discovery-class missions; in particular, additional comet sample return missions will allow the first laboratory studies to investigate the naturally occurring diversity among comets, a crucial scientific question for understanding not just the formation of comets but also the very nature of the early solar system. Though Stardust was highly successful, there are important lessons learned from the mission on which advances in aerogel technology can be based [3,4].

Lessons Learned : Specific aerogel advances are being studied in our work. The first deals with lowering the density and organic content of potential aerogel capture media made from silica. Stardust cometary dust samples were captured within the first few mm of cm thick aerogel blocks, with indications of transient heating to temperatures upwards of 1000 K. Reducing the density of the Stardust capture medium would allow the cometary dust to decelerate over a longer distance in the aerogel, reducing captured particle heating and production of melted aerogel, and significantly increasing the pristine nature and purity of the sample return.

Characterizing the amount and type of organics present in comets is a major scientific goal, with implications for the delivery of organics to early Earth and the presence of organics in the solar system. The Stardust sample return clearly showed the presence of organic material from the comet [5]. However, Stardust aerogel was found to contain up to ~ percent levels of carbon by mass in the form of organic impurities, with variable concentrations and contents. These impurities complicated the determination of the cometary organic component in the Stardust samples. This new work proposes to lower and characterize the organic content of silica aerogel capture media.

In addition, our work involves development of non-silica-based aerogel capture media. The Stardust samples show evidence that the cometary materials and the aerogel capture medium experienced alteration, including melting, during their capture in the aerogel. With a silica-based aerogel, this alteration is significantly complicating the interpretation of sample analyses, since silicon is a major atomic component of many planetary materials. This situation motivates development of a non-silica capture medium, such as tantalum-oxide (tantala, or TaO_x) based aerogel. Tantalum is a rare, trace element in planetary materials, and thus developing a tantala-based aerogel, to be flown along side the standard silica-based aerogel, would be a major advance for future missions that use aerogel to capture and return samples.

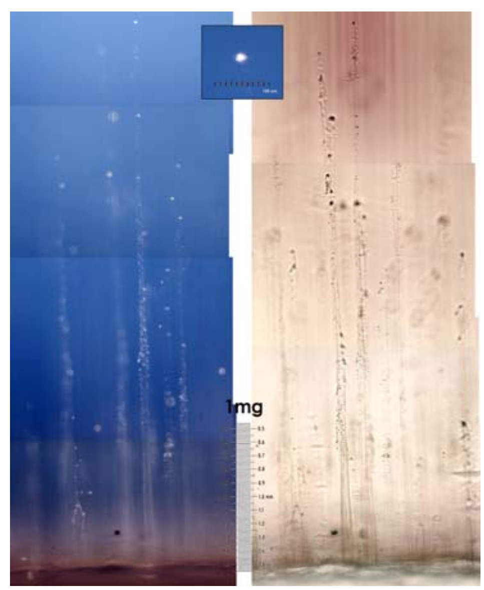

Figure 1 - Alumina sphere tracks in 1 mg/cm3 silica aerogel.

Work in Progress : In this work we report on progress to date on an internally funded aerogel technology development and test program, to develop improved aerogel capture media utilizing silica, tantala, and alumina-based aerogels with lower densities and organic impurity levels. We have fabricated and successfully tested 1, 3, and 10 mg/cc silica aerogels as well as 10 mg/cc tantala and 10 mg/cc alumina aerogels for their ability to capture hypervelocity particles (Figures 1 and 2). The aerogel media was cast directly into holders, which were then placed into a light gas gun for testing of projectile capture. A supercritical $C0_2$ extraction process was used to improve the organics content.

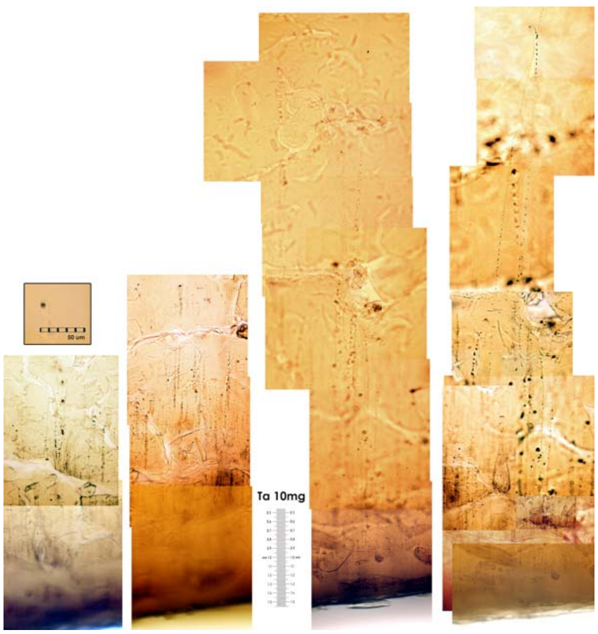

Figure 2 - Alumina sphere tracks in 10 mg/cm3 tantala aerogel. The wrinkled appearance of the material is due to minor warping of the aerogel surface.

References::

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